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ABSTRACT

This pilot study explored the characteristics of children's co-inquiry with a mentor and the changes occurring in their questioning with prolonged engagement in mediated inquiry. Six graduate students, who were practicing teachers, acted as mentors to individual students for inquiry into child-selected topics for 10 weeks. Children ranged in age from 5 to 13 years and were from a variety of ethnic and socioeconomic groups. Strategies used by the mentors included brainstorming to determine the children's prior topic knowledge and their current questions, experiments to explore specific questions, visits to sites pertinent to the topic, Internet sessions, and graphic organizers to record and examine data. Mediating children's inquiries involved modeling questioning syntax, mediating question sequences, and being actively involved in the inquiry. Interactive sessions were audiotaped. Co-inquiring pairs maintained Inquiry Journals in written or graphic format to record questions asked, resources consulted, findings obtained, and new directions for inquiry. Mentors maintained reflective journals and attended weekly graduate seminars on co-inquiry with the Principal Investigator. Findings revealed that children focused on the real topic of their inquiry around Week 3 or 4. When children experienced an anomaly or became aware of variables related to cause-effect relationships associated with the topic, they moved the inquiry toward a deepening study of the topic. Depth of study was contingent on time of exploration. Graphic organization of data was found to facilitate depth of inquiry and examination of relationships among variables. (Contains 34 references.) (KDFB)

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Changes in Children's Questioning During Guided Co-Inquiry With Mentors

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Changes in Children's Questioning During Guided Co-Inquiry with Mentors

Questioning is at the heart of inquiry. In all fields of study, a key to successful exploration is ability to hone the queries that direct the study. A hallmark of self-directed learners is their ability to ask questions that cut to the core of an issue and delimit perspectives on the problem to uncover its most influential factors. Despite children's innate curiosity, Dillon (1988) found little evidence of question-asking by students in classroom situations, where students are more often expected to answer questions than to ask them. Teachers' responsibility for covering the prescribed curriculum may deter them from soliciting children's genuine questions which could move classroom explorations away from the planned lesson (Biddulph, Symington & Osborn,1986).

Studies of student questioning, like that of Pizzini & Shepardson (1991), and Courage (1989) restate what Dillon (1988) discovered: that the skill of question-asking needs to be developed. According to Biddulph & Osborne (1982), children's questions appear to serve different functions: confirming the expected, resolving an unexpected puzzle, and filling a recognized knowledge gap. Some questions which children pose

contain invalid assumptions; others jump beyond the topic. When children were encouraged to pose questions to ask one another about the content of their reading, most of their questions were literal and text-bound (van de Meij, 1993). Because their questions were clearly influenced by the source materials and the task, van de Meij concluded that explicit instructions are needed to raise the level of children's questions.

In addition to learning the linguistic forms of effective queries, children also need strategies for locating resources, collecting information, and making sense of it all, in order to phrase new, more probing questions. Scardamalia & Bereiter (1992) point out that progressive inquiry, which really probes a topic, is rare in many school experiences. And, as Suchman (1962) discovered, children are often satisfied with one right answer, a tendency that is reinforced by requests for short-answer responses to questions posed by teacher, worksheet, and test. Learning how to inquire involves learning the language of questioning and logical reasoning, and the methods of research, i.e., being initiated into the culture of inquiry (Roseberry, Warren, & Conant,1992; Tishman, Perkins, & Jay;1995).

Feuerstein's theory of Mediated Learning Experience (Feuerstein,

Rand, Hoffman & Miller, 1980) explains ways in which children are helped by others to engage with their environment, revisit experiences, and internalize meanings, in the way Vgotsky (1978) proposed. This process of cognitive development includes imitation, repetition and variation, and comparative behavior, the precursors of relational thinking (Feuerstein, Rand, Hoffman & Miller, 1980, 34-35). Sternberg (1994) sees the child's question as a means of seeking mediation and identifies ways parents and adults, by their responses, may help or hinder the child's development of new schema.

Research on the development of creative people highlights the importance of early sustained interactions with a mentor about topics and questions of interest (John-Steiner, 1985). Collins, Brown & Newman (1989) call this "cognitive apprenticeship" because mentor and apprentice work together to explore a topic of interest in a co-inquiring way, as opposed to the student learning what the mentor already knows about the subject. The mentor both models questioning strategies through practice, and mediates the child's inquiry.

Training in Questioning

Imitation. Empirical research supports the value of modeling for

improving children's queries. Denney (1975) examined the influence of three types of modeling in the use of constraint-seeking questions on six, eight, and ten year olds: (1) exemplary modeling which illustrates how to ask questions; (2) cognitive modeling, which explains the strategy in use for exemplary questions; and (3) exemplary and cognitive modeling with self-rehearsal. Cognitive modeling alone was most effective for increasing the constraint-seeking questions of the children for solving Twenty Questions tasks. The youngest children were best served by the explanatory cognitive modeling. Both 4-to-6 years olds and elderly people improved their Twenty Questions problem solving when given examples of constraint-seeking questions and explanations of rules for formulating them (Denney, Jones, & Krigel, 1979). Teacher modeling of operational questioning with and without explanation of the process can increase the number of operational questions fifth and sixth grade students ask (Allison & Shrigley,1986). Modeling can help children ask more specific constraint-seeking questions for solving Twenty Questions tasks, and those who are given models and explanations of the cognitive processes involved become the superior problem solvers (Johnson, Gutkin & Plake,1991).

Training in Question Formulation. Pizzini and Shepardson (1991) used a program, SSCS (Search, Solve, Create, and Share) to teach fifth to eighth grade students strategies for problem solving, but not question formulation, in science lab instruction. Students applied the model to their lab work and the levels of their recorded questions during student-teacher and student-student interactions were compared over time. In both large and small group settings, the students asked more questions, but the cognitive level of those questions was unchanged. The students appeared to need explicit training in questioning and strategies for question formulation.

King (1991) studied questioning as a metacognitive prompt. She developed eleven questions to complement the stages of problem solving: planning, monitoring, and evaluating. King randomly placed same gender pairs of fifth grade students in three conditions for working with computer-assisted problems: guided questioning, unguided questioning, and control. The guided questioning group was given a card listing variations of the 11 different questions, and also experienced explicit cognitive modeling and practice in use of questioning strategies. Students in the unguided questioning group also experienced the cognitive modeling

of problem-solving strategies, but they were not given the card with question prompts. The control group received no training or instructions regarding how to question. All three groups participated in six 45 minute practice sessions over three weeks. King found that the guided questioning group was more successful than the other two groups in solving new problems and also performed better on the paper and pencil posttest of problem solving. Although the number of strategic questions asked by members of the respective groups was not statistically different, members of the guided questioning group asked strategic questions of one another twice as often as the other two groups. King believes that by providing the questions, she controlled the content of interaction between the pairs and encouraged more efficient and effective questioning and responding. Those in the unguided and control groups were less efficient, often interacting in unelaborated ways with one another about the problem. The use of questions may have taught the students in the guided group *how* to solve problems. King's findings also suggest that it is unlikely that students will ask strategic questions during problem solving without training. King (1990) also examined high school and college student control of questioning and noted the value of "freedom

within structure" in which students used generic questions to create their own. Students who did so demonstrated more self-regulation in learning than students who simply used given questions.

King and Rosenshine (1993) studied how fifth grade students, working in pairs, learned specific science content. One treatment group was given a prompt card with highly elaborated question stems (King, 1993, 134): "Explain why. . . .; Explain how. . . .; How does. . . affect . . .?; Why is . . . important?; How are . . . and . . . different?; Describe . . . .; What does . . . mean?; What is a new example of . . . ?; What do you think would happen if. . . ?; Why is . . . better than? A second treatment group received signal word question stems: " What. . .? Where. . .? Why. . .? How. . .? and Which. . .?" These groups were trained to use the question stems or signal words to question lesson content in a curriculum unit on tide pools, presented by their teacher. Working in pairs, the students asked each other questions and answered their partner's questions to stimulate discussion. During these interactions, differences in point of view and understanding were confronted and reconciled. The students in the control condition were not trained in questioning; their prompt cards simply instructed them to ask and answer one another's questions about the

lesson to help them understand and remember its content. The fifth graders who used elaborated question stems performed better on comprehension tests, retained more of the learned material, and constructed more complete and accurate knowledge maps than students in the other groups. Both guided questioning groups showed better retention of lesson material than the controls. Students given question stems asked integration questions more often than control students. Significant differences were not found between the performances of students receiving highly elaborated question stem training and those using less elaborated question stems, although there was some evidence of enhanced knowledge map construction by the former group.

Working with pairs of fourth and fifth grade students, King (1994) studied two types of guided questions: (1) lesson-based questions, used to assist students in constructing knowledge based on connections between concepts presented in the lesson and (2) experience-based questions, designed to do what the lesson-based questions did and, in addition, tap students' prior experience and knowledge. Students in the experience-based question group were given the same question stems that students in the lesson-based group received (those derived from the 1993 study

discussed above), and three additional question stems to increase student attention to applications of information, if-then relationships, and the use of prior knowledge: "How could . . . be used. . .?; What would happen if . . . ? ; How does . . . tie in with . . . that we learned before?" Students in the experience-based questioning group did better than students in the other groups on all measures. The posttest knowledge maps of the experience-based groups were more accurate and complete than those of the other students. However, strategy effects were not as great as hypothesized. King suggests that more practice in question generation using the question stems may show the value of question prompts like these and may uncover a superiority for the experience-based question stems. Martin & Pressley (1991) found that teaching children to use "elaborative interrogation" strategies enhanced their abilities to related new information to prior knowledge.

Lines of questioning. Much of the research literature on children's questioning examines the number and types of questions students learn to ask in response to given problems for which there are specific answers. This is related to, but different from, exploring lines of questioning that students may use to probe a topic of interest in open-ended ways. Whitin

(1993) documents an inquiry journey taken by his eleven-year-old daughter, Becca. Completing a typical arithmetic assignment in multiplication, Becca discovered that some equations resulted in identical solutions. Her curiosity piqued, she decided to investigate why this occurred. Becca began her investigation by asking: "Do you think '36 x 8' is the same as '48 x 6'?" She dissected 36 x 8 into the equations, 6 x 8 = 48 and 8 x 3 = 24. In the same ways, she divided 48 x 6 into the equations 8 x 6 = 48 and 6 x 4 = 24. She discovered no other identical products for additional factored equations on her worksheet, and asked, "Are there other numbers that work that way?" Becca proceeded to explore patterns with the guidance of her father's comments and questions, creating a chart to show factors for 12, 16, 18, 24, and 36. The description of this inquiry journey demonstrates the power of a child's self-selected exploration which is mediated by an adult's cognitive guidance. Becca's reflections on this investigation expressed her enthusiasm for "finding patterns", finding thinking strategies that can be useful with other problems, feeling challenged, and taking time to think.

The research on children's questioning tells us that ability to formulate strategic questions which move the learner beyond the simple

task of gathering information to finding patterns and interrelationships among facts and ideas, requires training. The most effective training provides children with models of well-phrased questions and guides them to understand how to formulate them. But this literature does not explain how children engage in open-ended inquiry or what changes occur in their questioning with prolonged engagement in mediated inquiry. Both issues are the focus of the reported pilot study and the larger project.

The Problem

During the summer of 1995, the principal investigator and four elementary teachers studied the questioning behaviors of three fourth grade children who participated in a seven-week study of animals which the children chose to explore. The children had difficulty formulating questions, asking mostly information-seeking and a few comprehension questions over the course of their explorations. Even as the children became more familiar with their topics, the questions, although more numerous, continued at the fact-seeking levels. They were concerned with obtaining single "correct" answers to their questions and were clearly frustrated by multiple responses to their questions. Mentor modeling did not appear to change this. With mentor prompting, some of the

terminology offered by the question stems adapted from King (1991; 1993) appeared in the questions the children wrote in their notebooks and in their interviews with resource people. The question stems did function to provide the language for higher order questions which the children did not formulate on their own. However, these questions seemed contrived, formulated to fit the stem, but not clearly meaningful to the children or always clearly pertinent to the focus of their explorations. Perhaps most interesting is the fact that, with or without question stems, the children did not develop lines of questioning, i.e., logically interrelated and elaborated question sequences that could help them delve into their topics.

This pilot study explores the characteristics of children's co-inquiry with a mentor to provide a type of informal apprenticeship that mediates children's inquiry and develops their skills of questioning. The study seeks variables for study regarding these questions: How can children's inquiry be mediated by mentors to develop lines of questioning? What can prompt children's questioning to move beyond superficial data collection to inquiries that have increasing depth?

Method

Co-inquiring pairs

Six graduate students, all practicing teachers, served as mentors to individual children for inquiry into topics selected by the children. Their co-inquiries extended for ten weeks during the fall semester of 1995. The children were selected by the students based on: (1) their availability for three hours each week, after school and on weekends, for ten weeks, including travel to different resources that were pertinent to their inquiry; (2) their reliability for participating in weekly sessions; and (3) their lack of experience and skill in investigative methods.

Each of the two kindergarten teachers in the group chose to work with kindergarten children. Esther, the five-year-old daughter of her mentor, is Anglo and middle class. Esther chose the topic of "trains" she said, "because they go very fast, they have wheels, and they carry stuff in their big boxes. I would like to ride a train and be a conductor." According to her mentor, Esther had seen trains regularly pass on the tracks behind their house, but had not explored them.

Jane, the five-year-old niece of her mentor, is Anglo and from a middle class background. To determine a topic of mutual interest, her

mentor generated a list of topics and presented them to Jane who immediately chose plants because, she said, "They have flowers." Jane was studying flowers in school.

The second grade teacher in the group co-inquired with her seven-year-old daughter, Patty, also Anglo, from a middle class background. At first, Patty could not define an interest, so her mentor shared with her some things that she wondered about. From this set, Patty selected the topic "cats".

A fifth grade teacher selected Eva, a fifth grade working class Hispanic child from her class. Eva has been diagnosed with Attention Deficit Disorder with Hyperactivity and is taking Ritalin. At the time of this study, the child was academically working below fifth grade level, with a reading level around the fourth-fifth grade range. When Eva and her mentor began their co-inquiry, they both identified interests in art. The focus on Van Gogh developed after a visit to a local art museum where Eva saw one of the artist's paintings.

A seventh grade teacher selected, Linda, a lower socio-economic Hispanic fifth grade girl from her church, whose first language is Spanish. Linda was suggested by her parochial school principal who also identified

the child's interest in plants. During their first session together, Linda took her mentor to her home to see her grandmother's garden, where she identified plants and their uses.

The oldest child in this group worked with a pre-school teacher. Jessica is her mentor's thirteen- year-old Caucasian/Native American neighbor. She selected the "mysteries" of Bermuda Triangle as a focus for inquiry because she had a brief encounter with the topic in her eight grade classroom and still had many questions about it.

Inquiry and Debriefing Sessions

Inquiry sessions began the week of September 11 and continued through the week of November 13, 1995. All co-inquiring pairs started with some attempt to assess the child's prior knowledge about the topic and to determine the child's questions. Charts were made to record what the child knew and wanted to find out about the topic; brainstorming on the topic produced webs of categorized subtopics. Over the course of the ten-week co-inquiry sessions, all the children and their mentors used library and multimedia resources, and interviewed people. All except the inquirers who explored the Bermuda Triangle visited sites that were pertinent to their topic and conducted "experiments" (formal and informal

manipulation of variables) to explore specific questions. The Bermuda Triangle exploration included an interactive session on the internet. All co-inquirers used graphic organizers, as described by Clarke, (1990), Tufte, (1988, 1990), and Moline (1995), to record and examine their data: webs, time lines, charts, inductive towers (which organize facts, showing interrelationships among them to establish knowledge claims that support generalizations, hypotheses, or new questions), deductive back maps (which detail the factors or evidence that support a generalization or hypothesis), and graphs. The interactive sessions were audio-recorded to capture the discussion, especially the questions the children posed as their inquiry developed.

Each Monday during the fall 1995 semester, the mentors met with the principal investigator for a three hour graduate seminar. These sessions included reviews of literature pertinent to co-inquiry with children, debriefing on the preceding week's co-inquiry sessions, and planning for forthcoming sessions with the children. During each co-inquiry meeting, adult and child explored the selected topic by using resources that they found to support their study and by applying inquiry strategies and graphic organizers that were examined during the graduate

seminars.

Data Sources and Analyses

The co-inquiring pairs kept Inquiry Journals to record the process and content of their explorations. Dated entries of each inquiry session recorded the questions posed by each co-inquirer, the resources consulted, the findings obtained, and new directions for further study of the topic. The younger children made graphic records of their research to accompany the written text provided by their mentor. Older children wrote their own narratives and notes about their explorations, inserting graphic presentations in the form of charts, diagrams, and graphs, as pertinent to their studies. Their mentors also recorded their own ideas about the topic in the same journal. Each Inquiry Journal was, therefore, a cooperatively maintained record of the questions, discussions, events, activities, and findings of the inquiry.

The mentors kept their own reflective journals which contain analyses of what was happening as child and adult explored their topic, with transcripts of selected excerpts from the audiotape recorded dialogues to illustrate questioning patterns, interpretation of their child's questioning, thinking, and learning, discussion of relationships of

research literature on children's questioning to the co-inquiry experience, and pedagogical insights into the inquiring method.

Interactions between co-inquiring pairs were captured on audio-recordings; they provide a record of what questions were asked, when, and by whom, and how questioning patterns changed over time. The data for each case were analyzed by the mentor and the principal investigator primarily to determine changes in each child's questioning over the duration of the inquiry, and also, to uncover variables affecting the mediated inquiry experiences of all co-inquiring pairs.

Findings

Analysis of the Inquiry Journals and the mentors' reflective journals showed consistencies across the six co-inquiring pairs, even given their different levels, backgrounds, and topics of interest. These common qualities of the children's inquiry and changes detected in their questioning patterns over time highlight some influential variables. These findings also suggest perspectives for studying children's apprenticeships in inquiry.

Children's Questioning

Finding one's true focus. During the first inquiry session, the

mentors asked the children what they would like to explore. The children seemed to have an idea of what they wanted to explore, but the true focus of their inquires was not always clearly articulated at the start. Only thirteen-year-old Jessica formulated many disconnected questions about the Bermuda Triangle mysteries during her first session with her mentor. But even in Jessica's case, the true query surfaced later. The breakthrough for all occurred about a third of the way into their inquiries—around the third or fourth week.

Five-year-old Esther's central interest in the speed and movement of trains was hinted at with her early questions: "How do they travel to and from the station? Why are some trains longer and some shorter?" After examining picture books on trains, and especially while observing model trains running in a transportation museum and real trains moving while stopped at a railroad crossing, Esther asked: "How do they move?" and "Won't it ever run out of gas?" Her ability to more clearly express her interest in speed surfaced when she became annoyed with the slow moving trains she observed at the Southern Pacific and Amtrack station.

Jane, also of Kindergarten age, wanted to study plants, "because they have flowers." She and her mentor started by using books on plants as

springboards for their discussion of what Jane knew about plants and flowers and what she wanted to find out. Jane's experiences with plants in her uncle's garden had taught her that plants need water and dirt and they are alive. During this first inquiry session, she expressed interest in buying some plants to grow, then wondered aloud, "How do plants grow?" As Jane and her mentor created a web of what they knew about plants, it became evident that Jane thought plants grew because they were bought at a nursery. So, her mentor decided that a day's tour of the countryside to examine native plants and flowers would be helpful. During the trip, Jane noticed what she called "balls and strings" (i.e., anthers and filaments of the stamens) in the center of flowers and expressed the belief that this is what made them smell pretty. During subsequent nature walks, Jane and her mentor picked flowers of different colors, sizes, and shapes. On closer examination of the flowers, Jane noticed that she could detect scents in some but not in others. Jane expected all the flowers with look-alike "balls and strings" to have a scent and was surprised to find that this was not always true. This anomaly gave rise to Jane's central issue: "Which part of the flower makes it smell?"

Seven-year-old Patty and her mentor began their exploration by

making a web of all the things they knew and wanted to know about cats. Some of Patty's questions were: "How came they have soft things on paws? Why do they walk on four legs? What is the tongue rough? Why do dogs chase cats? Why do they climb trees? Why do strange cats run away from you?" The pair identified resources to consult, starting with books. Patty cited information read in the books as answers to the questions that she or her mentor raised. She did not attempt to extend the questions but seemed to believe that once an answer was obtained, it was time to move on to the next question. Her mentor prompted the discussion with "This information makes me wonder", and Patty began to make "I wonder" statements too. However, Patty's attention often wandered from cats to other topics. It wasn't until after Patty and her mentor had revisited, at Patty's request, an exhibit titled, "Animal Supersenses" at a local museum that the child's real enthusiasm surfaced; "I want to know more about their senses, " she announced.

Eva expressed interest in studying art: places art can be found, supplies for creating art, and modes of art were initial categories which this ten year old suggested for exploration. Eva's first questions lacked focus: "Where did the artist come from? How did they create with color?"

An initial decision to focus on sculpture proved to be premature. Eva's questioning was labored. A hint of her real interest surfaced following the pair's visit to a local art museum. Eva said with assurance, "I think that I would like to study painting." When asked by her mentor if she wanted to study a particular artist, Eva identified Van Gogh, without hesitation. She asked: "What were his first and last paintings? What was his favorite, if he had one? Did he use black and white and did he use color? Why did he cut off his ear? Why was he interested in art?" Their follow-up visit to the library gave Eva too much print material on Van Gogh. She was overwhelmed by the wealth of printed material which she read uncritically. Once a question was answered by a text, Eva, like Patty, felt no need to pursue it further. The movie, *Lust for Life* sparked Eva's curiosity because it portrayed the human being behind the art. After viewing the film, Eva's questions began to examine interrelationships between Van Gogh's art and his psyche. When her mentor commented that Eva seemed to be asking more questions about Van Gogh's inner self, Eva responded: "Because he was so interesting. He was always trying to please others. He always gave and never took. He was in his father's shadow. Van Gogh started to listen to himself rather than his father. He

did what he wanted, by painting." Subsequently, Eva made clear the connection she was finding between Van Gogh's feelings of rejection with her own, associated with her parents' divorce.

Ten-year-old Linda seemed eager to have a one-on-one relationship with her mentor and to participate in taking trips to nurseries and back yards, to interview resource people, and conduct experiments to study seed germination and plant growth. But her focus frequently drifted and she remained dependent on her mentor's direction for the duration of their co-inquiry. A breakthrough of sorts occurred when her bean seeds did not germinate as expected, and she wondered: "Were they crowded?" Her mentor suggested planting some in an "uncrowded" condition. Linda suggested that these seeds were not growing, because they were "too deep in the soil". When she checked their depth, Linda discovered that they smelled bad, which bothered her, and during discussion of this finding, connected the smell of the dirt and rotting seeds to the smell of rotting food. Her disgust seemed to spark interest in the cause of the smell. Interestingly, Linda's questions were always formulated from observation, never during reflection on the experience.

Jessica knew that she wanted to explore the mysteries of the

Bermuda Triangle when asked because this topic had been encountered in her eight grade class earlier in the term. When invited to raise questions by her mentor, Jessica noted 35. Although they all pertained to Bermuda Triangle mysteries, the questions were not interrelated in ways to suggest a line of questioning. Among them were "What ever happened to Flight 19?, Why didn't any wreckage ever show up?, Why did the USS Sulfur Queen and twin ship disappear?, And whatever happened to the Cyclops?" These questions guided the search for books and magazine articles about Bermuda Triangle mysteries. When an extensive treatment of Flight 19 was found in one book, Jessica accepted the explanations with an uncritical eye. Like Patty and Eva, Jessica saw truth in printed text. The first evidence of Jessica's hypothetical reasoning and skeptical examination of data came after several conversations in which her mentor encouraged her to question information and opinions given by others, in print or conversation. Following these experiences, Jessica reintroduced questions to ask others, even though she had already obtained possible answers (e.g., "Do you think there were 15 or 14 people on Flight 19?" and "What do you think happened to the Cyclops and Sulfur Queen?") because, she said, she wanted other opinions. She also embedded hunches in her

questions: "Were there any weather patterns? Were there any patterns with the days or seasons with disappearances?" This interest in different weather patterns and the disappearance of ships and planes and the relationships among time of year and weather in the Bermuda Triangle did not develop into a deeper and sustained line of questioning until after collected data were organized.

Inquiry develops from a passion to find out, from the desire to accept a challenge. That may be the most defining quality of interest. And interest takes time to develop. All the children in this sample needed some direct acquaintance with their chosen topic before they could formulate meaningful questions about it. As the children interacted with the real thing, they became more immersed in the topic. As depth of study became possible, key qualities of the topic seemed to elicit the child's feelings. Esther, who had an increasingly evident interest in train speed, was more insistent about exploring train movement when she became annoyed by slow moving trains. Her interest in trains did not wane, it intensified as her feelings were piqued. A similar opportunity to recall an interest that had been expressed earlier, but not pursued, occurred during Patty's visit to a museum exhibit on animal senses. A day-long trip to the

country to see plants and flowers did not tire five-year-old Jane, but gave her more experiences with different types of flowering plants, her early expressed interest, and challenged her thinking about the source of the flower's scent. By connecting Van Gogh's personal needs to her own, Eva clarified her passion for understanding the artist's persona through his art. Jessica's enthusiasm about Bermuda Triangle mysteries developed as she challenged her own assumptions about where truth and knowledge reside. Linda, too, came closer to becoming interested in plants when she was frustrated by seeds that did not germinate and disgusted by the smell of rotting seeds.

Developing depth of inquiry. In some cases, movement toward developing deepening study of the topic occurred when the child experienced an anomaly. In others, the breakthrough occurred when the child first became aware of variables pertinent to cause-effect relationships associated with her topic.

Esther reasserted her early interest in speed when she began associating train length, cargo, and number of engines with its velocity. Although she was not adept at asking questions, Esther did respond to questions with hypothetical statements that suggested wonderings about

interrelated variables. For instance, when her mentor asked how she enjoyed the field trip to the train station, the following dialogue ensued:

Esther: "There was this most slowest train that I ever sawed in my whole life. It wasn't going fast. It was just the slowest train!"

Mentor: "Why do you think it was going so slow?"

Esther: "Maybe it had so much stuff that it was carrying."

At another time, when Esther and her mentor were stopped in front of a railroad crossing, watching a freight rain go by, Esther posed these unsolicited questions: "Where do you think this train is going? Won't it ever run out of gas?" The child seemed again to be thinking about cause-effect concerning momentum. Just two days after her mentor thought that Esther was losing interest in trains, the pair were on their way to school and had to stop at a train crossing. Theirs was the first car at the stop, so they could see the train quite clearly. The mentor decided not to say anything about the train. Esther took notice, though, and counted five engines. She began hypothesizing about the number of engines on a train and its relative speed. The child was clearly continuing to pursue her interest in speed and movement and was pondering influential variables.

Esther's drawings of trains became more detailed as the exploration proceeded. They show that she was attempting to relate the variables of type of cargo, number of cars, number of engines, and the number of wheels on each engine, to train speed.

Jane's interest in where scent is located in a flower seemed to be prompted by a construction activity in her kindergarten class: making a picture of a flower, showing leaves, stem, and petals. A perfumed cotton ball was pasted in the center of the petals. On their day's collecting trip, Jane and her mentor collected flowers with discernable scent. The mentor took one flower apart, examining petals, leaves, center of flower, and stem for scent. Jane continued this on her own, examining every flower they had collected. The two sorted the flowers by location of scent. Although Jane posed no questions, as such, her mentor observed that Jane was determined to prove the "balls and strings" in the center of the flower were the real source of a flower's scent. Jane wanted to smell the center of the flower first. However, she discovered that the scent did not always appear to emanate from the anthers. Jane's observations challenged her assumptions and brought her close to recognizing the location of nectaries at the base of the petals.

On several occasions, Jane expressed interest in what would happen to some bean plants she had planted if they put salt on a plant. She persisted with this and three weeks after planting the beans, she asked to put salt on the plant. Her mentor wrote:

> She put quite a bit of salt on the soil--you could see the white salt in little piles. Then we watered the plant and she added more salt. I told Jane we would look at the bean plant at about 9 p.m. Jane noticed that it was bent over (wilted). She predicted that it would turn brown and die. I asked her if she thought there was any hope for the plant, if there was anything we could do to "perk it up". Her response was negative. Jane drew "before and after" salt pictures of the bean plant.

Like five-year-old Esther, Jane's interests in certain aspects of her topic were retained over time, even if those interests were not the subjects of discussions with their mentors. Although these young children did not always clearly articulate what they wanted to find out about their topic, they did demonstrate hypothetical reasoning about cause-effect relationships that implied questions.

For ten-year-old Eva, a line of inquiry into Van Gogh's psyche

developed after viewing *Lust for Life* from which she gained a sense of the man behind the paintings. Her mentor wrote:

> It seems that the film has brought Van Gogh to life for Eva. She finally understood that Van Gogh's paintings were not just pictures of landscapes or people, but of his inner self. She came up with this conclusion immediately. She was also very interested in Van Gogh's relationship with Paul Gauguin and how Gauguin may have contributed to Van Gogh's breakdown. Her questions about Van Gogh's paintings were on a deeper level, i.e., Why was Van Gogh so interested in people? This question was sparked by a painting Van Gogh did of a landscape viewed from his window with a man in it. However, when he painted the scene, no one was in view. Eva wondered why he did this when all his portraits focused on real places and real people. Eva reasoned that Van Gogh included his imaginary man because he was following Gauguin's suggestion about painting the imaginary.
>
> Eva and I began our day by looking through more books on Van Gogh, specifically a collection of letters written by Van Gogh to his brother Theo. While skimming through the books together, we posed

more questions about the artist. Eva seemed to be focusing on the man behind the paintings rather than the paintings, themselves. She focused intently on why Van Gogh committed suicide. She saw there a link between the people in his life and his death. "The only reason he does something bad is when someone forces him," she said. I agreed with her to an extent but I realize that a deep-rooted sickness was involved.

Exploring a CD-ROM on Van Gogh, the co-inquirers examined Van Gogh, Gauguin, suicide, and painting. This multimedia resource prompted many questions: "What are the differences between Van Gogh's and Gauguin's painting? How much do his paintings sell for and why so much? Why was suicide considered romantic by some artists? Did people cause the actions in Van Gogh's life. . . religion. . . disease?"

Eva's mentor reflected:

Eva is looking deeper into subject than she was in the beginning. There is no longer just "fun time" but a serious inquiry to find out as much as we can about Vincent Van Gogh, the person.

Linda came close to seeing interrelationships among variables affecting plant growth when she detected a similarity between the rotting

smell of fungus growing on her planted seeds and fungal growth she had detected in a school experiment. Her mentor commented:

> One major breakthrough that I observed with Linda had to do with the smell. She was bothered a great deal by the smell and didn't even want to touch the dirt. Could this be an anomaly that sends Linda to a more in-depth study? After she analyzed what it smelled like feces, then we went on to finish the analysis. In the process, she began to relate what she could do to the plants to what they had done to food at school. She ultimately connected the smell of the dirt and rotting seeds of the smell of rotting food caused by fungus. She further decided to put some of the seeds in the dark and some in the light just like the food at school. I see this as a major connection and application.

However, Linda never did seem to connect the smell of the seeds and soil that didn't grow to rotting or decay, which is the major job of fungus. She did not seen to realize that what she was smelling was indeed the same thing that she had experienced at school. In time, it became apparent that Linda's interest was not in plants but in spending time with her mentor.

Sustained time and dialogue for inquiry. It seems obvious to say that depth of study is contingent on time of exploration. Even so, most curriculum units are short term. Early childhood teachers tend to plan their students' studies in very short time frames, usually allotting a few hours for a week or two to a particular topic of study. Upper elementary teachers plan units on selected topics (often in science and social studies) to last about three or four weeks, for about as many hours per week. (In this study, co-inquiring pairs often explored their topic in excess of three hours per week.) Most textbooks are written for short term and, frequently, superficial studies of topics even in the middle school. A surprising finding, especially for the early childhood mentors, was that all the children in our sample needed time to think and talk about what they were finding out before the substance of their interests became evident. Esther's mentor thought that she was getting tired of trains, that ten weeks was too long on one subject for a five year old. In retrospect, it seems to have been not long enough. By the tenth week, Esther was just developing her ability to articulate her interest in the relationship of speed and trains. Until that time, she relied on her mentor to direct the study. Similarly, Jane's mentor had been suggesting all the activities,

trying to guide Jane's involvement with plants. Jane needed some time following her mentor's lead before she asserted her interest in finding out what salt does to plants. As indicated earlier, all the children were just getting warmed up to their topics by the third or fourth week. This seemed a function of their increasing knowledge. The more they knew, the better prepared they were to probe their topic, to formulate better informed questions, and to know where to look for answers.

Graphic Organization of Data. Even as the children gathered more information about their topics, they tended toward information-surfing, often attending to isolated facts rather than searching for interrelationships among variables. Lots of information overwhelmed them. In some cases, text hindered. In all cases, graphics helped.

Both Kindergarten children, Esther and Jane, insisted on drawing to record their experiences. Esther's mentor noticed that her drawings became more detailed and complex as her study of trains developed. Jane's drawings of flowers paid special attention to the parts she found interesting and, like Esther, Jane used drawings to synthesize the data she was gathering through her study. Esther was helped to place trains in developmental perspective by the time line she drew and illustrated.

Patty, the second grader, although a good reader at her level, was somewhat intimidated by text. Her mentor noticed that she would jump to conclusions after reading because she would make leaps of faith from what her mentor called, "bytes of information" to generalizations the separate "bytes" seemed to support. Patty was sometimes overwhelmed by the amount of information she encountered at once, and needed help organizing it to detect patterns. Just as the time line helped Esther make sense of changes in trains over time, that graphic form also gave Patty a way of sequencing the information she gathered about prehistoric, ancient, and contemporary cats, thereby answering her questions about which cats co-inhabited the earth with other animals in eras that had been depicted on television programs she had seen. Another graphic form that helped Patty to see patterns in her "overwhelming" collection of data was the Venn diagram, which made visible the distinct and shared characteristics of domestic and wild cats.

A Venn diagram helped Eva sort out differences between the paintings of Van Gogh and Gauguin. But Eva's greatest need for help in interpreting information occurred after she and her mentor had read Van Gogh's letters to his brother Theo. Eva's real interest was in Van Gogh,

the man: the person behind the paintings. At the start of the study, Eva, who was not a strong reader for her level, used text in superficial ways, taking everything at face value rather than questioning for information that seemed to be missing in the text. By the time she elected to read Van Gogh's letters, she was willing to read more deeply, but that produced a glut of data. The inductive tower (Clarke, 1990) provided the organizational framework Eva needed to link the seemingly disparate pieces of information found in the letters, forming inferences and hypotheses.

Linda had difficulty in finding interrelationships among pieces of data she collected throughout her inquiry. Part of the difficulty was attributed to her limited language skills in English or Spanish and to her lack of keen interest in the topic of plants. Nevertheless, an inductive tower, which she recorded in her inquiry journal, with her mentor's help, shows her initial attempts to explore connections between the characteristics of her rotting seeds and her prior experience with fungal growth on foods.

A noticeable change occurred in the questions that Jessica posed about Bermuda Triangle mysteries after she completed an inductive tower

in which she examined the evidence for Flight 19's disappearance. The graphic presentation of information caused her to ask: "Why, with the ships, is it (the weather) mostly bad, and with the planes, it's not? It's mostly good weather?" Her mentor noted that although Jessica could discern the connections between bad weather and the destruction of a ship, she did not seem to be able to connect two variables, such as bad weather and the fact that many of the disappearances happened during the late fall and early winter (November-January). Jessica did not appear to make the connection between inclement or turbulent weather and increased disappearances in the months of November, December, and January. Her mentor guided Jessica to make a chart showing the type of weather for each occurrence and the month in which it happened. The charted data was then graphed to clearly show what type of weather occurred during particular months and the number and type of disappearances per month. She developed a hunch that human error and migrating birds probably had as much to do with plane disappearances as inclement weather had to do with ship accidents in the Bermuda Triangle.

Developing Lines of Questioning. In the summer 1995 pilot, one of the three children demonstrated ability to ask related elaborated

questions when interviewing a veterinarian about the internal temperature and hearts of snakes. Her questioning started with a general query: "Why do snakes have to have a certain temperature?" Then, building from the veterinarian's response, the child asked, "What's the normal temperature? And, after another response, "Can a snake have a heart attack?" Although the child's elaboration is minimal in this incident, her questions show her initial attempts to spontaneously build questions from information given during interaction. In the fall 1995 study, two incidents were recorded showing children's elaborated questioning. Like the summer incident, these also involved the children's dialogues with people who were knowledgeable about the topic of conversation.

Seven-year-old Patty and her mentor had prepared some questions to ask their neighborhood veterinarian, but the child was shy and reluctant to pose any of them at the start of the interview. Her mentor initiated the interview with some questions they had planned about vaccinations and noted:

> As the veterinarian began to explain about vaccinations, Patty became very attentive. She began asking questions that had not been planned. She asked him what rabies was, then through new

questions which built on his responses, about what other viruses or bacteria animals should be vaccinated against, and if there were any vaccinations that are given to cats and not to other animals, and why.

During the interview, Patty developed another question sequence about cats and water. Her mentor wrote:

> Patty asked the veterinarian why all cats hate water. He told her that contrary to popular belief, not all cats do hate water. He said that this depends a lot on the cat's personality, though most cats did prefer not to get wet. Patty asked if maybe it was because they did not like to be cold. She told him that she loves to take a bath but hates to get out of the warm water and feel cold. She said that maybe cats felt that way too. I was surprised by this comment as well. This sounds as though when she received information that conflicted with information she had found in print resources, she began looking for other causes for the effect of cats not liking water.

In these episodes, Patty built from the veterinarian's responses to her questions, relating what he said to the knowledge she had been

acquiring about cats, to form new questions. Each new question extended the exploration further, in the manner of an incisive interviewer.

In Jessica's study of Bermuda Triangle mysteries, the first evidence of her ability to formulate a line of questioning based on response in a dialogue occurred when she connected with a book discussion on the internet. She posed the question: "Does anyone know anything about the Bermuda Triangle?" A response from a NASA consultant. named "Diane" here, led to Jessica's elaborated questioning. A greatly abbreviated sample of that interaction follows:

Jessica: "Tell me what you know about it."

Diane: "Atmospheric pressure defaults and hides the ships. . . ."

Jessica: "Why do you think atmospheric pressure does it?

Diane: "It creates (a fog) if you will, that deadens the radar. . . . When warm and cold fronts meet and create a disturbance causing the ships and planes to lose direction."

Jessica: "How do you know about this?"

Diane: "Part of my job (as consultant to NASA) is to investigate weather and atmospheric changes."

Jessica: "What do you think happened to Flight 19?"

Diane: "I don't know."

Jessica: "Were there any weather patterns or were there any weapons that shot them down?"

Diane: "I don't believe there were any weapons involved. Easiest way to find information concerning this matter is to look into exposed files."

Jessica: "Do you know anyone that can help us out?"

Diane suggested government agencies and document sources. Through this dialogue, Jessica became aware of the influential factors of weather and atmospheric changes—a connection that focused her inquiry on specific causal factors, guided her search for weather/seasonal patterns that might help explain the mysteries, and encouraged her skeptical view of explanations she encountered in texts.

Jessica's mentor commented:

At the beginning of our inquiry, Jessica formulated her questions from her experience with the topic. She continued to do so until I assumed a more active role in the inquiry by asking my own questions. Her internet conversation was very enlightening for it

> demonstrated her ability to formulate a question based upon a response (new piece of information), thus increasing the depth of her original question. . . . Jessica's ability to formulate questions with some depth appeared to increase when she is involved in conversational interactions.

Questioning is a linguistic enterprise. Learning to use the question as a tool for learning seems to be aided by dialogue with another who is knowledgeable about one's interest. Learning how to develop elaborated questioning sequences involves listening for clues an pertinent information, phrasing questions that seek elaboration and explanation of the information and ideas given, and building new questions from these findings until the questioner arrives at resolution or a better sense of direction for the inquiry.

Discussion

Findings from these cases are consistent with early experiences with inquiry that are reported by and about talented and creative people (Gruber and Wallace, 1989; Skekerjian, 1990). John-Steiner's (1985) analysis of the backgrounds of creative people documents the importance of informal apprenticeships during childhood. In some cases, a parent

provided for continuing dialogue about how to observe and question. For others, a friend or teacher was the catalyst for thinking. According to John-Steiner, children's thinking is nurtured by long-term involvement and regular sustained dialogue with a mentor. John-Steiner differentiates the experiences of privileged children, who may have several tutors and family members who help to mediate their learning, with those of children who may rarely have the sustained attention of an adult at home or in school. Each mentor in this study noted that teacher-child co-inquiry is difficult to manage and sustain in the regular classroom. However, the value of inquiry for children's learning that co-inquiring pairs realized over the course of our study made us all wish that similar experiences could be offered to all children, especially those least likely to have this type of personalized attention for academic inquiry. What do these findings suggest are critical components of an apprenticeship in inquiry?

Mediating Children's Inquiry

Modeling the syntax of questioning. All the children needed help in formulating researchable questions. Mentor modeling of question-asking seemed effective for all the children. Verbal language development was

clearly a factor in the cases of the five year olds and the ten-year-old bilingual child. (The latter had limited proficiency with English and Spanish.) The other children in the sample sometimes were hampered by inexperience with the syntax of question formulation. When given models, they soon were asking questions in the modeled way. Even so, many of their questions had to be solicited. And their language needed editing to help the children examine interrelationships among variables they may have identified but not connected. Developing this question-asking skill seems to require more than the provision of examples to emulate and question stems to develop. Children can mimic a question raised by an adult or express wonderment about the same things adults want to understand, but meaningful questions are not phrased in contextual isolation. They arise from knowledge, thoughtfulness, and opportunities to dialogue about a topic.

Mediating questioning sequences. Beyond modeling, it was important for the mentors to guide the children's formulation of question sequences to help them focus and deepen their explorations. The mediation of children's inquiry demands sustained one-to-one dialogue about a topic with the goal of helping children formulate finely honed

statements about what they want to find out. This means asking questions designed to solicit questions, with an eye to the logical relationships of significant variables. While some teachers are highly skilled in doing this (Doris, 1991), this skill is not commonly developed in teachers, nor is the attendant mindset which prizes queries over responses.

All the mentors listened for their children's formulation of lines of questioning which suggested depth of reasoning about some aspect of their topics. One of the most consistent observations of the mentors was that their children needed opportunities for sustained one-to-one interaction with another who was interested in their topic in order to develop depth of questioning. The only exception was ten-year-old Linda whose real interest in being alone with an adult for extended periods of time each week transcended the topic selected for study. Linda's interest in this type of closeness became evident as she and her mentor explored plants. Her selected topic turned out to be irrelevant. This, coupled with her linguistic limitations, prevented Linda's questioning from deepening over the ten weeks of study. For the five year olds, the most significant interactions were with their mentors and, although they did not

demonstrated lines of questioning in any one episode, they did return to specific ideas periodically, as Esther did with motion and speed and Jane did with flower parts and location of scent. Logically connected questioning sequences developed in the other children's studies when they had opportunity for extended one-to-one dialogue. This occurred for Patty when she interviewed the veterinarian. Her questions became more probing and sophisticated as she built on the information he shared, questioning him further, especially about vaccination for pets and humans. For ten-year-old Eva, questioning sequences about Van Gogh's inner self developed when she and her mentor interacted about their respective understandings of his letters. Jessica's internet conversation with the NASA consultant gave the first sign of her ability to probe for answers to her questions about weather and disappearances. Depth of questioning and reasoning about the cause-effect relationships of weather, human error, and plane and ship disappearances was evident relatively late in her studies, while dialoguing with her mentor. When mentors and children actively built on one another's ideas or when the children and their interviewees did so, depth of reasoning and questioning ensued. Why weren't we able to elicit more question sequences from the children? The

answer is suggested by what we found missing. The mentors talked of needing to practice skills of inquiry themselves. They felt that, by fine tuning their own inquiry processes, they could more effectively guide the children's research into topics about which they knew a great deal or very little. They needed to become more skilled at probing a subject. Some of the questions they found useful in guiding the children's inquiry might have been effective in helping children formulate question chains if they had been asked in succession. For instance, these individually useful question types might be especially powerful when combined:

- Questions that elicit ideas about what children want to explore:

  What do you wonder about?; What do you chat about?
- Questions that attempt to narrow the field of exploration: What do you want to find out?; What specific things do you want to look for?
- Questions that search for relationships: What is this like?; What do you think might be causing this?; What patterns do you see?
- Questions that connect to resources:

Where would you look to find out?; Where would you go?; What would you do?; Who might know?

- Questions that ask for questions:

How would you ask someone about this?

The idea is here is to use generic questions, like King's (1990;1993) question stems to make children more aware of their options for exploration. But, rather than supply children with stems that encourage fill-in, look-alike questions for studying given content, these generic queries encourage children to formulate questions in their own language and for open-ended study of their interests.

There is more to this issue than simply soliciting questions. During this pilot study, the children's best questioning sequences occurred when they were engaged in conversation with a knowledgeable adult. Each response to their questions provided information which was specifically focused on their interests. The children did not have to pore over texts or search databases to try to locate relevant answers. Because clues were immediately forthcoming, the children could work with them, thinking about their connections to their prior knowledge and their most intriguing issues. They could then distill the most salient information from each

response, folding it into a new question and keeping the interactive sequence tightly tuned in to what they wanted to find out.

Some children learn how to do this during dinner table conversations. But many may never have such experiences during childhood. In many classrooms, sustained adult interactions about academic content with one child at a time are infrequent. Less likely is interaction that solicits question sequences through give and take that supplies information and clues which children can probe, compare/contrast, combine, and hypothetically test through a whole string of related queries.

Mentor's active engagement in inquiry. The mentors in this study found that the single most critical enabling factor was their own active engagement in the inquiry, their own comprehension of the logical relationships among pertinent concepts and painstakingly uncovered clues. The mentors' knowledge of how to inquire and their own investment in and passion for the study made it possible for them to naturally guide the children's processes of detecting and reasoning. But they had to be aware of their two-pronged responsibility: to simultaneously delve into the topic and to guide the novice's exploration.

Directions for Further Study

It was unlikely that any of the children in our sample would have explored their topics in as much depth if they had not been working with a mentor. There are many possible reasons for this, e.g., the child's desire to please the mentor and have time with an adult, to go places, to do things, and because the adult provided resources and suggested directions for exploration that enhanced the study. By working with others who could model questioning and provide help in analyzing and synthesizing collected data offered, the children developed their skills in using tools of exploration and enhanced their content knowledge of their topics.

The act of co-inquiring with one child during this study caused the mentors to reexamine their roles in mediating children's explorations. They became more sensitive to the need for extended dialogue to deepen the child's exploration and encourage lines of questioning. However, the mentors felt ill prepared to help children formulate question chains. Teacher training in conducting open-ended inquiry, in exemplary modeling of questioning and questioning sequences, and cognitive modeling of strategies for building probing questions from information and clues

contained in responses seems indicated. This training should also include ways of sustaining dialogue with individual students, ways of soliciting question sequences by responding to student questions with information that students can use to formulate new questions in a line of questioning about a specific focus. Teachers who interact with children in these ways can influence children's growth as questioners.

The long term focus of this research is to determine the type of training teachers need to effectively mediate children's open-ended inquiry in the regular classroom. The next phase of this project will involve teachers and their lower SES minority students in public schools in exploring the following questions:

1. What effect will training teachers in how to sustain children's question sequences by soliciting questions and by responding with clues that children can use to build new questions, have on individual children's lines of questioning during dialogue about a topic of study?

2. What changes will occur in children's questioning patterns given exemplary and cognitive modeling in formulating lines of questioning for open-ended inquiry?

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